REMARKS

This amendment is in response to the Office Action dated July 1, 2004. Entry of this Amendment and reconsideration of this application are respectfully requested.

Claim Rejections under 35 USC 112

Claims 2-4 were rejected as being indefinite: the Examiner asserts that claim 2's "said step of spatially adjusting" is indefinite because its parent claim 1 has two different "spatially adjusting" steps.

Claims 2-4 have been cancelled.

Claim Rejections under 35 USC 103(a)

Claims 1-3, 5-6, 9-10 and 24-26 were rejected over a patent to Kalend et al. in view of Yanagita et al.

Claim 1 has been amended to better clarify the distinctions that exist between it and the cited art. As amended, claim 1 is directed to a method of visually documenting historical changes in biological tissue. The method comprises:

- obtaining a first image of a region of tissue;

- obtaining pathological feature data for the region of tissue;

- obtaining a second image of the region of tissue using a first level of resolution;

- digitally storing the first and second images as digitized first and second images;

- spatially adjusting at least one of the first and second digitized images to spatially register the images so that corresponding features in both images are mapped to corresponding positions, the spatially adjusting comprising:

- determining a coordinate transformation which produces at least a pre-determined degree of correlation between

the first and second digitized images; and

- applying the coordinate transformation to at least one of the first and second digitized images, to align the images;

- the coordinate transformation determined by:

- applying coordinate transformations of scale, position and rotation to one of the first and second digitized images, to obtain a plurality of corresponding adjusted images;

- cross-correlating the adjusted images with one of said first and second digitized images, to produce a correlation output; and

- selecting a coordinate transformation which produces at least a defined correlation output from its corresponding adjusted image;

- the cross-correlating comprising:

inputting the first and second images to an optical correlator, and

reading the correlation output from an output of the optical correlator;

- correlating the pathological feature data with the second image to define a historical region-of-interest (ROI) in the second image;

- rescanning the defined ROI using a second level of resolution higher than the first level of resolution to obtain a third image;

- spatially adjusting at least one of the historical and rescanned ROI images to spatially register the ROI images so that corresponding features in both images are mapped to corresponding positions; and

- creating from the historical and rescanned ROI images a composite image which visually emphasizes temporal differences

between the ROI images, thereby visually emphasizing historical changes between the historical and rescanned ROI images.

As amended, claim 1 recites a very detailed and specific method of visually documenting historical changes in biological tissue. The method requires obtaining a first image, a second image, and a rescanned image. The method requires obtaining pathological feature data and using it to define a region of interest (ROI). The method requires that the spatial adjusting of the first and second images be performed in accordance with a specified detailed procedure which employs an optical correlator.

Virtually none of these steps are disclosed in the cited art. The patent to Kalend describes an X-ray system that is largely unrelated to the claimed optical correlator-based image processing method. Kalend's system utilizes a manual concept of coarse and fine alignment, based upon either operator interactivity or the use of opaque fiducials which are manually positioned on the patient. Kalend's patent allows two X-ray images (a "simulation image" and a "portal image", see col. 4, lines 26-43) to be processed digitally so that they can be displayed for comparison. The images are first coarse aligned using a transform generated from seed points selected interactively - i.e., by a human user - from the two images, or through detection and identification of x-ray opaque fiducials placed on the patient. Then a fine alignment of the images is performed by selecting intersecting regions of the two images and enhancing those regions by use of a motion flow algorithm.

Kalend's use of selected seed points is an impressive approach for a spatial alignment process, but has two flaws. First, the "coarse alignment" is triggered by either operator interaction or a mechanical registration device (opaque fiducials). Both of these are limited by the resolution of

placement of the pointer by the operator or physical placement of the opaque fiducials by the technician during the procedure. Second, all alignment is done in the spatial domain, which is limited by image dynamics and pixel intensity.

As recited in the amended claim 1, the present method does not utilize mechanical or physician interactions to align the image sequences. Claim 1 has been amended to explicitly require that the spatial adjusting of images involves the determination of a coordinate transformation which requires cross-correlating the adjusted images, with the cross-correlating performed by an optical correlator. As such, the techniques employed by the amended claim 1 and Kalend are completely different. Several elements of claim 1 are analyzed with respect to Kalend below:

"(b) obtaining pathological feature data for said region of tissue;"

This is described in the specification from page 5, line 16 to page 6, line 2, where it is explained how such data concerns a feature in a ROI that has been previously identified, or is found in a pathological feature library, for example.

The Examiner asserts that Kalend discloses this step in column 7, lines 50-65. However, the applicant can find nothing concerning the subject matter of this element in the cited text: the cited paragraph discusses coarse and fine image alignment, but says nothing about pathological feature data as recited in the claim and defined in the specification. Kalend fails to disclose this element.

"(e) spatially adjusting at least one of said first and second digitized images to spatially register said images so that corresponding features in both images are mapped to corresponding

positions, said spatially adjusting comprising:

determining a coordinate transformation which produces at least a pre-determined degree of correlation between said first and second digitized images, and

applying said coordinate transformation to at least one of said first and second digitized images, to align said images;

said coordinate transformation determined by:

applying coordinate transformations of scale, position and rotation to one of said first and second digitized images, to obtain a plurality of corresponding adjusted images,

cross-correlating said adjusted images with one of said first and second digitized images, to produce a correlation output, and

selecting a coordinate transformation which produces at least a defined correlation output from its corresponding adjusted image;

said cross-correlating comprising:

inputting said first and second images to an optical correlator, and

reading said correlation output from an output of said optical correlator;"

This step explicitly spells out the detailed means by which the first and second images are to be spatially adjusted. As amended, the claim specifies the determination of a coordinate transformation which requires cross-correlating the adjusted images, with the cross-correlating performed by an optical correlator.

The Examiner states that this step (as previously amended) is disclosed in Kalend at column 5, lines 33-66. But as noted above, the cited text describes a manual means of aligning

images. As noted in column 5 at line 36, the coarse alignment is generated "interactively" - i.e., with the guidance of a human operator - or using opaque fiducials which are manually placed on the patient. Both of these techniques are comparatively simple, conventional approaches which bear no resemblance to the optical correlator-performed cross-correlation and resulting coordinate transformation required by the amended claim 1.

This represents a very substantial difference between Kalend and the claimed invention: the two approaches result in completely different methods, as well as very different levels of performance. For example, the specification makes clear that the claimed optical correlator-based procedure is a product of the frequency domain (see, e.g., page 21, lines 4-11; page 22, lines 2-14), whereas Kalend's approach is a product of the spatial domain. It is known that operation in the frequency domain provides finer resolution than is capable in the spatial domain.

Furthermore, Kalend's use of fiducials or seed-points limits the number of registration points, which can induce false information into the final output by improperly warping the image signals in areas not defined by Kalend's registrations. Kalend could overcome this by providing a large number of registration marks; however, to accomplish this would mean risking loss of signal information through opaque fiducials that cover a large area, or due to the extra operator time required to define the seed points between image signals. In contrast, the claimed method is limited only by the information within the image signals, which is extracted within the frequency domain.

Another difference between the two technologies is that Kalend's approach is based upon point-to-point comparisons, whereas the claimed method is based upon geometric shapes as defined in the frequency domain through a cross-correlation process. Therefore, the claimed method is linked to the patient's

anatomical content, rather than the image content of pixels as in Kalend.

Another difference is that Kalend's opaque fiducials are external to the patient, with the registration points based on external references. If the anatomical object of interest or ROI has shifted internally, accuracy will be lost. Such cases may be caused by patient weight gain or loss, plastic structures (e.g., breast implants), or orthodontic areas (e.g., tongue, mouth open/closed). In contrast, the claimed method is based upon internal geometric information of the image signal, and thus suffers no such limitation.

In summary, the differences in the means employed to spatial adjust multiple images are vast, and critically important. The applicant asserts that Kalend's failure to disclose anything resembling the claimed registration method renders it largely irrelevant to the present inquiry.

"(f) correlating said pathological feature data with said second image to define a historical region-of-interest (ROI) in said second image;"

This element clearly specifies the use of the pathological feature data referred to in step (b). However, as noted above, Kalend does not retrieve or generate such data. As such, Kalend cannot and does not "define a historical region-of-interest" as required by this element.

The Examiner states that this element is disclosed in column 8, lines 3-26. However, a careful reading of this text finds no mention of pathological feature data, or of defining an ROI based on such data.

"(g) rescanning the defined ROI using a second level of

resolution higher than said first level of resolution to obtain a third image;"

This step clearly requires that the defined ROI be rescanned. The step is described from page 6, line 37 to page 7, line 9, which explains that the step is performed "with scanning ultrasound equipment but with a finer level of resolution."

This step - which plainly requires the acquisition of a new, third image - is not disclosed in Kalend. The Examiner states that this step is disclosed from column 7, line 66 to column 8, line 26. It is not. That text describes an iterative mathematical procedure for processing the "sim" and "portal" images, but this procedure clearly does not involve the acquisition of any new images. There is no third image involved, and nothing is rescanned. As such, this element cannot be and is not disclosed in Kalend.

"(h) spatially adjusting at least one of said historical and rescanned ROI images to spatially register said ROI images so that corresponding features in both images are mapped to corresponding positions;"

It was noted above that Kalend discloses no "rescanning" step, and produces no rescanned image. The text cited by the Examiner again refers to mathematical processing of Kalend's "sim" and "portal" images - no third, "rescanned" image is produced or suggested. Therefore, it is impossible for Kalend to disclose step (h), which explicitly requires a rescanned image.

"(i) creating from said historical and rescanned ROI images a composite image which visually emphasizes temporal differences between said ROI images, thereby visually emphasizing historical

changes between said historical and rescanned ROI images."

The Examiner concedes that this step is not disclosed in Kalend, instead citing Yanagita for its disclosure. However, as was noted in the amendment filed in response to the previous Office Action, Yanagita also fails to disclose a rescan of a defined ROI to produce a rescanned ROI image. Lacking a rescanned image, Yanagita cannot and does not disclose the subsequent creation of a composite image from historical and rescanned ROI images which visually emphasizes temporal differences between the ROI images - as is explicitly required by this claim element.

In summary, the approaches taken by Kalend and the applicant differ fundamentally in both their details and their results. The cited art fails to disclose most of the elements of the amended claim 1, including at least steps (b), (f), (g), (h) and (i), and particularly step (e)'s very specific and complex spatial adjusting of images by means of a coordinate transformation produced using a cross-correlation which is a product of an optical correlator.

In view of the all the above-stated reasons, the applicant asserts that claim 1 would not have been obvious in view of the cited art at the time the invention was made.

As the limitations of claim 2-4 have been incorporated into the amended claim 1, claims 2-4 have been cancelled. However, it should be noted that the applicant disagrees with the Examiner's contention that the limitations found in claims 2 and 3 are disclosed in Kalend. Claims 2 and 3 require that the spatial adjusting of step (e) involve:

1. applying coordinate transformations of scale, position and rotation to one of the first and second digitized images to

obtain a plurality of corresponding adjusted images,

2. cross-correlating the adjusted images with one of the first and second digitized images to produce a correlation output, and

3. selecting a coordinate transformation which produces at least a defined correlation output from its corresponding adjusted image.

The text in Kalend from column 5, line 65 to column 6, line 24 does, in fact, describe an alignment procedure. However, it does not disclose the claimed alignment method. Specifically, the described affine transformation does not involve the cross-correlation, correlation output, and coordinate transformation selection steps mandated by the claim language (now incorporated into the amended claim 1).

As such, the text cited by the Examiner concerning claims 2 and 3 does not overcome the arguments for patentability put forth above for the amended claim 1.

The amended claim 1 is the parent of claims 5-6, which are therefore allowable along with claim 1.

The amended claim 1 is also the parent of claims 9-10, which are therefore allowable along with claim 1.

It should be noted that claim 10 is also allowable on independent grounds. Claim 10 requires that the composite image of claim 1 visually emphasize temporal image differences by representing various regions of the composite image in synthetic colors, based upon temporal image differences between the historical and rescanned ROI images. This is not disclosed in the cited art.

Yes, Yanagita discusses the use of color, but claim 10 also requires the disclosure of the use of historical and rescanned

ROI images, the creation of a composite image from such images, and the use of synthetic colors to emphasize temporal image differences. All of these aspects are required by claim 10. Simply mentioning the use of color does not constitute the disclosure of the several facets and requirements of claim 10 - all must be disclosed.

As the cited art lacks disclosure of virtually all the facets and requirements of claim 10, claim 10 is allowable on this independent basis.

Claim 24 has been cancelled.

The amended claim 1 is the parent of claim 25, which is therefore allowable along with claim 1.

It should further be noted that claim 25 is also allowable on independent grounds. Claim 25 requires that pathological feature data correspond to predetermined image shapes or characteristics retrieved from a pathological image library. This is not disclosed in Kalend. The Examiner states that this is disclosed in Kalend in column 7, lines 54-57. Yes, "geometric shapes" are mentioned there, but where is there any mention of predetermined image shapes or a "pathological image library"? Claim 25 specifically recites "predetermined image shapes or characteristics retrieved from a pathological image library". This is not disclosed in Kalend. Claim 25 is therefore allowable on this independent basis.

Claims 7 and 27 were rejected as obvious over Kalend in combination with Yanagita and Wang.

The amended claim 1 is the parent of claims 7 and 27, which are therefore allowable along with claim 1.

Claims 8 and 28 were rejected as obvious Kalend in combination with Yanagita and Mitchell.

The amended claim 1 is the parent of claims 8 and 28, which are therefore allowable along with claim 1.

It should also be noted that claims 8 and 28 are also allowable on independent grounds. Each requires that at least one of the historical and rescanned ROI images be a three-dimensional image. However, it was noted above that neither Kalend nor Yanagita discloses a "rescanned" image as required by these claims. Nor does Mitchell. Lacking disclosure of the required rescanned image, it is impossible for Kalend, Yanagita and Mitchell to disclose the limitations recited in claims 8 and 28. Claims 8 and 28 are therefore allowable on this independent basis.

Claims 4, 19 and 21 were rejected as obvious over Kalend in combination with Yanagita and Trezza.

Claim 4 has been cancelled.

Claim 19 is an independent claim directed to a system for enhancing imagery of bodily tissues by relating earlier and later images. It has been amended in a manner similar to that of claim 1.

As amended, the system of claim 19 requires:

- an image processor, programmed to:
    - receive a first image of a region of tissue;
    - obtain pathological feature data for the region of tissue;
    - obtain a second image of the region of tissue using a first level of resolution;

- register the first and second images by controlling an optical correlator to find a position of correlation between the first and second images, the registering of the first and second images comprising:

- determining a coordinate transformation which produces a pre-determined degree of correlation between the first and second images, the coordinate transformation determined by:

- applying coordinate transformations of scale, position and rotation to one of the first and second images to obtain a plurality of corresponding adjusted images,

- cross-correlating the adjusted images with one of the first and second images to produce a correlation output, the cross-correlating comprising inputting the first and second images to the optical correlator and reading the correlation output from an output of the optical correlator,

- selecting a coordinate transformation which produces a defined correlation output from its corresponding adjusted image; and

- applying the coordinate transformation to at least one of the first and second images, to align the images;

- correlate the pathological feature data with the second image to define a historical region-of-interest (ROI) in the second image;

- rescan the defined ROI using a second level of resolution higher than the first level of resolution to obtain a third image;

- register the historical and rescanned ROI images by controlling an optical correlator to find a position of correlation between the historical and rescanned ROI images;

- derive a composite image from the historical and rescanned ROI images;

- compute temporal differences between the historical and rescanned ROI images; and

- emphasize the temporal differences in the composite image; and

- an optical correlator coupled to the image processor and arranged to perform the correlations.

As amended, claim 19 recites a very detailed and specific system for enhancing imagery of bodily tissues by relating earlier and later images. The system requires an image processor arranged to obtain first, second and rescanned images. The system requires obtaining pathological feature data and using it to define a region of interest (ROI), and that first and second images be registered in accordance with a detailed optical correlator-based procedure.

The cited art fails to disclose many of these system elements. As noted above, the patent to Kalend describes an X-ray system that is largely unrelated to the optical correlator-based image processing method of the present application. Kalend's system utilizes a manual concept of coarse and fine alignment based upon either operator interactivity or the use of opaque fiducials placed on the patient. Kalend's patent allows two X-ray images to be processed digitally so that they can be displayed for comparison. The images are first coarse aligned using a transform generated from seed points selected interactively from the two images, or through detection and identification of x-ray opaque fiducials placed on the patient. Then a fine alignment of the images is performed by selecting intersecting regions of the two images and enhancing those regions by use of a motion flow algorithm.

Kalend's "coarse alignment" is triggered by either operator

interaction or a mechanical registration device. Both of these are limited by the resolution of placement of the pointer by the operator or physical placement of the opaque fiducials by the technician during the procedure. As recited in the amended claim 19, the present system does not utilize mechanical or physician interactions to align the image sequences. Claim 19 has been amended to explicitly require that the spatial adjusting of images involves the determination of a coordinate transformation which requires cross-correlating the adjusted images, with the cross-correlating performed by an optical correlator. As such, the systems employed by the amended claim 19 and Kalend are fundamentally different.

The other cited references fail to make up for the shortcomings of Kalend. Neither Yanagita nor Trezza disclose spatial adjusting by determination of a coordinate transformation which requires cross-correlating the adjusted images, with the cross-correlating performed by an optical correlator - as is explicitly required by the amended claim 19.

Several elements of claim 19 are analyzed with respect to the cited art below:

- an image processor, programmed to:

"(b) obtain pathological feature data for said region of tissue;"

As noted above in connection with the amended claim 1, Kalend does not disclose this element. Nor do Yanagita or Trezza.

"(d) register the first and second images by controlling an optical correlator to find a position of correlation between said

first and second images, said registering of said first and second images comprising:

determining a coordinate transformation which produces a pre-determined degree of correlation between said first and second images, said coordinate transformation determined by:

applying coordinate transformations of scale, position and rotation to one of said first and second images to obtain a plurality of corresponding adjusted images,

cross-correlating said adjusted images with one of said first and second images to produce a correlation output, said cross-correlating comprising inputting said first and second images to said optical correlator and reading said correlation output from an output of said optical correlator,

selecting a coordinate transformation which produces a defined correlation output from its corresponding adjusted image, and

applying said coordinate transformation to at least one of said first and second images, to align said images;"

This step explicitly spells out the detailed means by which the first and second images are to be registered. As amended, the claim specifies the determination of a coordinate transformation which requires cross-correlating the adjusted images, with the cross-correlating performed by an optical correlator.

Kalend describes only a manual means of aligning images. As noted in column 5 at line 36, the coarse alignment is generated "interactively" - i.e., with the guidance of a human operator - or using opaque fiducials which are manually placed on the patient. Both of these techniques are comparatively simple, conventional approaches which bear no resemblance to the optical

correlator-performed cross-correlation and resulting coordinate transformation required by the amended claim 19.

As noted above, Yanagita and Trezza also fail to disclose this element.

"(e) correlate said pathological feature data with said second image to define a historical region-of-interest (ROI) in said second image;"

This element clearly specifies the use of the pathological feature data referred to in step (b). However, neither Kalend nor Yanagita and Trezza retrieves or generates such data, nor do they "define a historical region-of-interest" as required by this element.

"(f) rescan the defined ROI using a second level of resolution higher than said first level of resolution to obtain a third image;"

This step clearly requires that the defined ROI be rescanned. This step - which plainly requires the acquisition of a new, third image - is not disclosed in the cited art. The Examiner states that this step is disclosed in Kalend from column 7, line 66 to column 8, line 26. It is not. That text describes an iterative mathematical procedure for processing the "sim" and "portal" images, but this procedure clearly does not involve the acquisition of any new images. There is no third image involved, and nothing is rescanned. As such, this element cannot be and is not disclosed in Kalend, nor in Yanagita or Trezza.

"(g) register said historical and rescanned ROI images by

controlling an optical correlator to find a position of correlation between said historical and rescanned ROI images;"

It was noted above that the cited art discloses no "rescanning", and produces no rescanned image. The text cited by the Examiner again refers to mathematical processing of Kalend's "sim" and "portal" images - no third, "rescanned" image is produced or suggested. Therefore, it is impossible for Kalend to disclose step (g), which explicitly requires a rescanned image.

"(h) derive a composite image from the historical and rescanned ROI images;

(i) compute temporal differences between said historical and rescanned ROI images; and

(j) emphasize said temporal differences in said composite image;"

None of the cited art, either alone or in combination, discloses this combination of elements.

In summary, the cited art fails to disclose most of the elements of the amended claim 19, including at least steps (b), (d), (e), (f), (g), (h), (i) and (j), and particularly step (d)'s very specific and complex registration technique involving a coordinate transformation produced using a cross-correlation which is a product of an optical correlator.

By failing to disclose or suggest all of these elements of the amended claim 19, the applicant asserts that claim 19 would not have been obvious in view of the cited art at the time the invention was made.

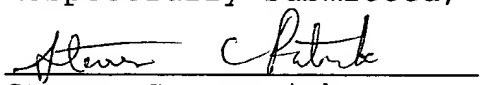
The amended claim 19 is the parent of claim 21, which is therefore allowable along with claim 19.

Claim 22 was rejected as obvious over a combination of Kalend, Yanagita, Trezza and Wang.

The amended claim 19 is the parent of claim 22, which is therefore allowable along with claim 19.

All of the claims presently in the application are believed to be patentably distinct with respect to the cited art and to otherwise be in proper form for allowance. A Notice of Allowance is respectfully requested.

Respectfully submitted,



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